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ABSTRACT

Material on instructional computing drawn from various reports, surveys, and recommendations was assembled for use by the Communications Review Committee at the University of Michigan. The Committee was charged with the responsibility of examining the potential impact of media and instructional technology upon the University. A report, aimed at providing it with relevant information, begins with a brief history of the instructional use of computers at the University. This is followed by a section offering examples of instructional-related uses, including drill, skills practice, programed and dialog tutorials, testing and diagnosis, simulation, gaming, information processing, computation, problem solving, model construction, graphic display, the management of instructional resources, and the presentation and display of materials. The third segment relates activities at other universities, and the fourth reviews some conclusions from national studies. Recommendations for instructional computing are presented and the report concludes with a view of the future. Appendixes offer a bibliography on computers in college teaching, a review of University expenditures for instructional computing, and a list of University of Michigan schools and departments reporting the use of computers for instructional purposes. (LB)

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Contributions of Computing to College Teaching and Learning Activities at the University of Michigan

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November 30, 1972
(revised June 1, 1973)

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CONTENTS

Introduction 1

Brief History 3

Examples of Current Uses 5

Activities at Other Universities 11

General Conclusions from National Studies 13

Recommendations 17

A View of the Future 20

Appendices

A. Selected Readings on Computers in College Teaching 23

B. University Expenditures for Instructional Computing 28

C. Schools, Departments and Offices Reporting Use of Computers for Instruction, 1972-73 31

INTRODUCTION

These pages have been assembled as a working paper on instructional computing at the University of Michigan for use by the Communications Review Committee. The material has been drawn from reports, surveys and recommendations regarding computing in the instructional program of the University. A new survey is in process by the University Committee on Computer Policy and Utilization, and results and recommendations may be expected in the summer of 1973.

The Communications Review Committee was appointed by President Fleming in the spring of 1972 to review the functions, goals and administrative organization of University broadcasting and audio-visual services. The potential for educational innovation through electronic and other media was of particular concern to the committee, and the impact that new instructional technology may have on the University during the next decade. Members of the committee were: Thomas Gies, professor of finance (chairman); Stanford Ericksen, director of the Center for Research on Learning and Teaching; David Felbeck, professor of mechanical engineering; Garnet Garrison, professor of speech; Whitmore Gray, professor of law; Jack Hamilton, director of university relations; William Hays, associate vice president for academic affairs; James Hayward, professor and chairman of oral surgery; Howard Peckham, director of Clements Library and professor of history; Michael Radock, vice president for university relations; Alfred Storey, director of Extension Service; and Robert Suave, staff person for the committee.

A number of arguments have been made for reviewing computers in the instructional process now; many of them relate to bringing consultation on instructional computing within the broader concerns of resources for learning and teaching.

> The University spends more on computers in the instructional process ($555,000; see Appendix B) than it does on television, films, radio and other technological aids combined (excluding books).
>
> Instruction resources may be wasted through inefficient computing software and perhaps ill-advised computer instruction projects.
>
> Soon most students entering the University already will be literate in the use of computers; faculties will experience increasing pressures for student computing.
>
> The business of education is changing from storage and transmission of facts to development of process and judgment; computing is a dynamic medium for processing information and testing models of process.

This report is addressed not only to the Communications Review Committee but to faculty and students of the University interested in more effective use of the computing facilities for instruction. Often a user can borrow ideas from another user on campus and sometimes from activities at other institutions.

The University resources for computing are now seen by most users to be limited, but available resources can be extended through increased coordination of development efforts and more careful management of expenditures for equipment and services.

The seven sections of this report are arranged in a logical sequence from history through current uses to recommendations and a view of the future. Some readers will want to begin with the section giving recommendations for the University (page 17). The appendices provide leads to further information either from published reports or from individuals at the University of Michigan concerned with use of computers for instruction.

BRIEF HISTORY

Computers have been in use at the University of Michigan since the early 1950's when the staff at Willow Run Laboratories designed and constructed MIDAC, one of only twenty high-speed electronic digital machines in the country. In 1955 the University installed an IBM 650 computer which served to introduce a number of faculty members and graduate students to the capabilities of digital computers and to give the computing staff opportunities to experiment with such problem-oriented languages as IBM's FORTRAN and to develop its own translator, GAT.

In 1959 the University received a three-year Ford Foundation grant for the development of the use of computers in engineering education. The objectives were fourfold: (1) the training of the engineering faculty; (2) the development of introductory computer courses for undergraduate engineering students; (3) the publication of useful teaching literature; and (4) the production of a large body of completely solved, computer-oriented, engineering problems suitable for use as classroom guides and samples. Success in all four areas spread to other schools of engineering and, eventually, to other schools and departments in the University.

The University's Computing Center was established in 1959 with the installation of an IBM 704 computer and continued to grow through development of capabilities on the IBM 709, 7090, and 360 series machines which followed. The present systems, an IBM 360/67 full duplex machine, has been in operation since 1968 and provides faculty members and students with access to a machine that is larger, faster and more versatile than any of its predecessors. In the development of languages and system configurations, particularly for general-purpose time-sharing and remote access computing, the Computing Center has remained among the leading centers in the country. Campuses at Flint and Dearborn participate in the use of this facility, as do other colleges in southeastern Michigan.

The Center for Research on Learning and Teaching was established in 1962 at the University of Michigan to provide service to the faculty and conduct research on the basic problems and conditions of instruction that may be of concern to the faculty and students. In 1964 it initiated a program of research and development on instructional use of computers. Today the Center provides consultation and assistance for faculty of the University using computing in the instructional process, and research staff pursue new developments in programming languages and instructional strategies.

The MERIT Computer Network project and its parent committee on information systems (MICIS) plan for cooperation in instructional computing resource utilization at the University with similar centers and facilities on the campuses of Michigan State University and Wayne State University. Since 1969, with the support of the Michigan Legislature and the National Science Foundation, MERIT has been engaged in development of a resource-sharing, computing network in the state. Operation began in April of 1972, with regular service among all three campuses established in October of 1972. Presently, staff at the three universities are working cooperatively through a computer communications system and associated software to establish a more varied and perhaps more economical source of computing for educational

uses than would otherwise be possible with each institution working individually. Activity at the University for network uses of computers was recognized nationally when in October 1972 Educom (Interuniversity Communications Council) held a conference in Ann Arbor on the theme "networks and disciplines." The MERIT Network was officially dedicated in May 1973 and participation extended to all colleges and universities in Michigan.

The Computing Center and the Center for Research on Learning and Teaching together provide most of the computing resources and consultation services which apply to instructional uses on campus; the MERIT Network provides contact with other schools regarding cooperative development and sharing of resources. These three offices are at the hub of communication about computer-related curriculum development; many schools and departments have organized substantial activities, including consultants, special software, courses, and sometimes small computers. Most of these are identified in Appendix C.

In September 1972 the Center for Research on Learning and Teaching initiated a series of informal meetings for a special interest group on instructional computing within the University. The group has examined the possibilities of borrowing curriculum and equipment from the PLATO IV system at the University of Illinois (see page 11), reviewed the implications of computing networks for instructional uses, looked at computing activities in the School of Education (see page 8), and discussed topics of special interest (e.g., programming languages, data bases, and graphics).

The budget for student use of computing is second only to that of student use of libraries among learning resources at the University. The Computing Center faced serious problems of overload in 1972-73; access for student learning activities has been cut back for many units. Review of resources for instructional use of computers is therefore quite timely.

EXAMPLES OF CURRENT USES

For readers new to the area of instructional computing, selected uses at the University are listed according to kind of computer use. The headings may help organize the domain for discussion and for the conclusions and recommendations which follow.

Instruction and Learning Process

- Drill
- Skills practice
- Programmed tutorial
- Testing and diagnosis
- Dialogue tutorial
- Simulation
- Gaming
- Information retrieval and processing
- Computation
- Problem solving
- Model construction (procedural)
- Display construction (graphic)

Management of Instruction Resources

- Student records
- Materials files

Preparation and Display of Materials

- Generating films and graphs
- Generating tests on an individual basis
- Automatically editing and analyzing text materials
- Representing substance in new ways

The listing of computer uses under these labels does not do justice to the contributions by various individuals to the curricula. Uses in teaching at the University are too complex to be categorized so simply, and the reader should contact the department or school for more details (see Appendix C). Many of the descriptions of this section are taken from "A Representative Sample of Computer-Related Instruction Activities and Facilities at the University of Michigan," prepared by Karl Zinn and Molly Espey for the Michigan Interuniversity Committee on Information Systems, March 1971. A revision of that survey is in preparation for distribution by September 1973.

Programmed tutorial, testing and diagnosis

A series of ten tutorial programs teach students in library science the use of reference works, including encyclopedias, biographies, yearbooks, directories and others. Build-in quiz sequences provide immediate diagnostic testing.(T. Slavens)

The History Department at Flint has constructed a series of exercises designed to enable the students to: test themselves when they are ready through the use of stored quizzes; utilize ancillary materials such as games; and analyze historical material such as iron industry data as a means for studying history and also as a means of becoming familiar with quantitative methods of research. (R. Schafer)

The Department of Foreign Languages at Flint has developed several interactive programs which help students master basic word forms of French and Spanish.

Dialogue tutorial

Library patrons simulated by computer provide decision-making situations for the students in library science via a dialogue in which the computer plays the role of selected clients who need assistance in choosing a reference work. (T. Slavens)

An exercise in the application of one of the Federal Rules of Civil Procedure has been prepared and used intermittently in Law School classes. The student, after reading the facts of the case, assumes the role of a lawyer who must decide which motion to make on his client's behalf. The program explores with him the results of his choices. Practice in logic and decision making using "normalized" statutes is being explored with another program. (L. Allen)

Computer-based dialogues have been developed to guide the student in the derivation of proof for physical concepts. The student is allowed to make independent attempts to derive a physical principle from more fundamental ones; he finds more individual attention to his needs than in most recitation sections. (N. Sherman)

Simulation and Gaming

A series of macro-economic models of increasing complexity have been developed and used as instructional tools in several undergraduate economics courses. The most complex- model currently in use represents a world composed of ten essentially equivalent countries. Students in the role of decision makers enter information from computer terminals scattered around the campus; the solution program utilizes their decisions, together with other predetermined information, to solve for new values of all relevant variables. In this fashion students share an experience in macro-economics at a rate of about three quarters of a simulated year per week of the class term. (R. Holbrook)

A computerized game has been developed in the School of Education which simulates a practicum experience for the training of educational researchers and/or evaluators. (L. Collett)

A special package of computer programs is used to generate data for student experience in a first psychology course in research and design. The computer procedures fill in for expensive laboratory equipment and procedures without sacrificing intellectual challenge. (D. Main)

A sophisticated simulation model of factors involved in site planning has been developed in the School of Architecture. The student determines the position of a building on a plot of land, given relevant constraints and selection of design criteria.(H. Borkin)

The computer is used for species evolution simulation in the field of zoology. The programmed model simulates in successive generations the relative proportions of five types of organisms in each of three geographical regions. With slight modifications, the model can be used for either plant or animal populations. The model is designed to teach concepts of population genetics and evolution by simulation and modeling techniques.(A. Kluge)

The School of Public Health uses several computer simulation exercises in the classes. One allows a student to observe Typhoid epidemics, and to control them through medical control measures (vaccination) or through improvement in environmental sanitation. Another simulation allows the student to study the most economical location of landfills in a geographical region. A cost-effectiveness simulation model is used for studying the control of air pollution.(R. Deininger)

The School of Dentistry has undertaken a computer-based instructional program to assist the faculty in reaching their teaching objectives. Presently staff are working on various computer programs which will allow the student to test himself, to simulate diagnostic situations or to view various patterns of facial growth. (D. Starks)

Simulation models provide practice in management of a living resource system in the School of Natural Resources. For example, the student examines the past history of a salmon fishery and then attempts to ensure a profitable long-term operation by discovering the optimum management strategy through interaction with the program. Other models and gaming situations involve management of forests, fire control resources and wildlife. (W. Benteley)

Information retrieval and processing

A conversational data-retrieval program used in political science and sociology generates tables reflecting the composition of the sample population for ISR's 1968 Election Survey. A capacity for detailed stratification encourages original investigation by users otherwise unacquainted with computers. (B. Bowen)

A personalized information storage and retrieval system was designed for use by individuals working with large bodies of information. The user may enter a variety of textual materials and assign descriptions to them which make it possible for these materials to be retrieved later. The system has been used for studying scientific problem solving, assembling a large data base for student research projects, and maintaining the continually changing information files of a graduate seminar. (W. Reitman)

Chemical Abstract Service provides professors and students with a variety of aids for research and teaching. Chemical Titles is a biweekly, computer-readable journal that reports the titles of selected papers recently

published in approximately 650 current chemical journals. Through the MERIT Information Center, Chemistry division, subscribers obtain individualized printout of current titles according to interest profiles. (R. Taylor)

Computation and problem solving

A library of statistical routines was prepared by which students in education can test hypotheses against real data provided by the computer. The student selects whether to use the entire population or a random or stratified sample in calculating his chosen statistics. An on-line pre-test of each statistical concept "unlocks" access to those calculation aids which the student may wish to use. (D. Starks)

The Physics Department at Flint has developed specialized programs for analysis of lenses in an optics laboratory, for the study of relativity and for use in an elementary physics course. (D. Boyes)

Students in several statistics courses in the School of Education utilize the computer for convenient application of statistical models, such as linear regression, and variance and covariance analysis. (M. Johnson)

Students in both graduate and undergraduate courses in Landscape Architecture employ the computer to obtain calculations necessary in the layout of physical plans for building complexes, streets, roads and the like. (H. Deardorff)

A computer model has been used by students in Naval Architecture to run mathematical routines in order to design a ship's propeller. The student tests the implications of what he is doing in the design process. (H. Norvacki)

An introduction to data processing, particularly information storage and retrieval systems, has been developed so that students in public health courses may use these powerful tools in various studies. (R. Deininger)

Model and display construction

The Department of Geography is developing procedures for convenient retrieval and processing of geographic information. A variety of computer programs are available to students for the automatic production of maps by electronic line-drawing equipment. Programs dealing with statistical treatment of geographical data have been published in a booklet, and a computer movie, "Simulating Urban Growth in the Detroit Region," was produced using a demographic model developed to describe population growth with particular emphasis on geographical distribution. (W. Tobler)

Materials files

An educational experiment at MHRI using a "Growing Encyclopedia System" (GES) aims to present accumulating knowledge to learners at different levels with increasing sensitivity to their needs. It goes beyond typical computer-assisted instruction in that it directs learners to the growing literature,

to excerpts, to the other topics which are logically connected - when such directions are needed. It has been implemented for a mathematics course for 5 terms. Computers have been used in producing, revising and using this dynamic directory. Supplementary to the Math GES is a practicum, "Programming Exercises," to teach computer programming by doing. (M. Kochen)

The Medical School's Committee on Academic Affairs has been responsible for the development of a lecture compendium which provides up-to-date information regarding the content of course presentations. Student aides generate phrases describing the content of each lecture; these are edited by the lecturer and stored in the computer. A special retrieval program provides access for an instructor who wants to determine what has been previously covered in his assigned teaching area, and for the Committee on Academic Affairs and others who make decisions regarding curriculum revisions. (R. Kahn)

Generating films

Using an on-line graphics display system, numerical simulations are made of certain experiments in senior engineering courses. Students can enter arbitrary values for the thermophysical system with the computer displaying the actual data and a graphical representation of the theoretical behavior of the experiment. Computer-generated films of simulated natural phenomena are being produced to provide for viewing in large groups. (R. Phillips)

Films of complex spatial events are being generated by computer for use in astronomy classes. (R. Teske)

Generating Tests

In association with individually paced instruction, proficiency tests are generated by computer on demand. At any time a student can request a test on a unit of the course and receive one different from those for all students preceding him but covering the same material at about the same difficulty level.

Analysis of Text

A series of computer-based exercises is used by students learning basic journalistic skills in news story writing. Students are given facts about a news event through mimeographed handouts, research reports, or films. In batch or time-sharing mode, the computer checks and comments on the student's write-up of the story, especially with respect to the lead, names, addresses, organization or ranking of facts. The computer also checks on stylistic characteristics such as readability, overuse of passive verbs, and on mechanical style, such as punctuation, or hyphenation. Computer assistance given directly to students improves performance and attitudes, and reduces overall costs of writing instruction. (R. Bishop)

Representing Substance in New Ways

Some parts of the Internal Revenue Service Code are being restated with the help of a computer editing program in a "normalized form" better suited for study and application. Students study the representation of statutes generated with the help of a computer editing and formatting program; the data base also services for computer-aided retrieval and analysis of the Code. (L. Allen)

A Note on Cost-Savings with Computers

Robert Bishop in the Department of Journalism has taken over responsibilities for nine sections of a writing course with eight or nine teaching fellows and computer assistance. Previously each section of 20 to 25 students was handled by an individual on the regular teaching staff. Costs of such instruction (at the lowest rates for assistant professors) were about $2000 per section. Presently the sections are handled by teaching fellows who are paid about $1200 per section. The course is supervised by a regular staff member, in this case, Professor Bishop, and assisted in an important way by computer checking of writing style.

In addition to the $1200 for the teaching staff for one section, each student spends about $15 of computing time, adding about $300 to costs for the section. The immediate savings over the previous method of handling the writing course is about $500 per section of 20 to 25 students. Furthermore, one does not have the overhead associated with regular teaching staff, or the pressure to create additional upper division courses or more interesting teaching. In actuality, so many sections of the writing course would almost certainly not be provided without computer assistance.

Apart from savings in the institutional budget, the students spend about half as much time in class and appear to accomplish much more with the same or greater satisfaction in the class. Informal evaluation studies conducted by Professor Bishop and others during the last 2 or 3 years show better writing performance.

Another point of comparison for cost is the tuition payment for these students. At a rate of $20 per credit hour, each student is paying about $80 for this four-hour course. Twenty students in a section provides a budget of $1600 were this rather specialized course expected to pay for itself. Surely not many sections providing as much individual attention and checking of individual creative work would come close to matching the tuition costs (without overhead).

ACTIVITIES AT OTHER UNIVERSITIES

Engineers at the University of Illinois, Urbana, have designed a computing system (called PLATO for Programmed Logic for Automated Teaching Operations) especially for effective and efficient use in education. It is a large system intended to provide instructional computing to over 1,000 simultaneous users throughout the University and in a number of other colleges and schools in Illinois. The design includes notable advances in the technology for graphical display and special arrangements for efficient communications through broadband channels of the telephone system. University of Illinois faculty and users at other institutions are authoring computer-based curriculum materials. The PLATO system has been of considerable interest to universities and school systems in other states. Some universities, among them Indiana, Iowa, Iowa State and Florida State, are exploring the need and requirements for installation of PLATO systems. Some persons at the University of Michigan are considering trial use of PLATO terminals in Ann Arbor connected to Urbana by telephone lines. Some of the curriculum materials have attracted interest (biology and population dynamics, in particular).

TICCIT (Technology for Interactive Computer Controlled Informational Television) is a name given to systems being developed by Mitre Corporation in McLean, Virginia. The first version of an instructional system is designed especially for use in a small college. It is based on a medium-sized computer system and video technology to obtain low-cost instruction with over 100 simultaneous users. The hardware and software designs have been coordinated with the development of instructional materials. Instructional design teams at Brigham Young University in Provo, Utah will provide materials for basic and remedial instruction in mathematical and language skills at small colleges. The video technology should be of interest to system planners at the University of Michigan; the procedures and curriculum of this first TICCIT system will not be useable directly.

Stanford University operates a computing system which distributes instructional computing to a number of centers through the country. It is a large-scale, service operation at present, depending on long distance telephone communications to connect remote sites with a central computer. Satellite computer systems control clusters of student terminals at remote centers usually associated with elementary school demonstration projects and special education institutions. The service operation is conducted in parallel with an extensive program of research and development at the Institute for Mathematical Studies in the Social Sciences, Stanford University. Curriculum materials have been prepared for young children (elementary school), learners with special difficulties (for example, the deaf) and certain university courses (especially second language learning). The language courses could be of value to university students; they could be implemented on a computing system on campus.

Dartmouth College has demonstrated the ability of an institution of higher education to make computing as available to students as the library or science laboratory. Essentially all students at Dartmouth College learn about computing and are expected to make effective use of the computer throughout their four years of study. All disciplines of study at the college have been affected, including language instruction, history, and

art as well as various areas of science and mathematics. The same computing system is used by a number of other colleges and secondary schools within convenient telephone distance of Dartmouth College, and has been duplicated at other institutions and in commercial time-sharing services. Although the Michigan time-sharing system is superior to the Dartmouth one in many respects, the Michigan system is less available to and less suitable for many students outside of computer science and engineering.

A multi-disciplinary group at the University of Texas at Austin is engaged in development of computer-based science and engineering education. The expertise of faculty members in various departments and colleges is applied to develop and evaluate computer-based undergraduate curriculum materials to improve instruction in various disciplines. In addition to engineering subjects the project encompasses physics, chemistry, zoology, psychology, sociology and economics. A project staff expert in computers and educational technology provides hardware, instructional procedures and evaluation models. Two of the objectives of the NSF-sponsored project are to identify concepts of computer-based education which are common among several disciplines and to determine the elements of successful transfer of educational packages from one institution to another.

Many other colleges and universities in North America are pursuing interesting developmental projects and worthwhile operations with computers in education. A small but rapidly increasing percent of pre-college instruction includes computing experiences, especially in science and humanities. The five projects mentioned above have large budgets or visible impact, but they represent a small portion of the total instructional computing activity.

GENERAL CONCLUSIONS FROM NATIONAL STUDIES

Some advice about computers in college teaching can be taken from recent studies of national scope.

General Recommendations for Higher Education

Points of advice for administrators, faculty and students is offered in the last chapter of The Emerging Technology: Instructional Uses of the Computer in Higher Education by Roger Levien (McGraw-Hill, 1972).

Administrators should seek to create an environment in which the computer's potential to assist in the instructional process can be explored free from extraneous impediments and subject to positive support. Among the steps that can be taken are:

1. The conduct of careful cost-effectiveness analyses of areas of potential use for the computer in instruction. This implies the gathering of more-specific-than-usual cost data on conventional instruction.

2. Encouragement of faculty participation in experiments with and development of computer uses by providing teaching time to develop materials, support for the necessary computer use, programming assistance, and rewards for those who succeed.

3. Encouragement of cooperative efforts with other institutions in which instructional materials are shared.

4. Selection of modes of computer service for instructional purposes that facilitate the sharing of instructional materials with other institutions, especially off-campus centralized time-sharing systems or on-campus minicomputers programmed by standardized cassettes.

5. Assignment of a portion of the instructional budget to support the development of computer materials that will be: subject to careful cost and effectiveness evaluations; designed to be usable at other campuses; and feasible and acceptable for use on the local campus.

6. Introduction of budgeting and decision-making procedures that encourage consideration of the cost-effectiveness of alternative instructional technologies.

Faculty should seek to develop effective instructional uses of the computer that:

1. Are suitable for more than local use;

2. Make full and imaginative use of the computer's capacity; and

3. Draw upon the skills and experience of other faculty in the same and related disciplines.

To this end, faculty within a discipline should encourage the formation of discipline-wide groups for joint development of instructional materials.

Faculty members should seek to exploit effective instructional computer uses in their classes in ways that will retain the instructor's independence and participation while expanding the range of learning tools open to his students.

Students should demand that the faculty experiment with instructional computer uses and employ them regularly when they prove to be cost-effective.

Development of Curriculum Materials

The following comment on faculty role and incentives was excerpted from The Use of Computers in Higher Education: Perspectives and Policies, OECD Centre for Educational Research and Innovation, Paris, 1971.

The role of the scholar in curriculum development must be acknowledged since it is he who must largely determine and attend the scope and structure of the knowledge base, and explore its internal logic. Development centers should be established within, or in cooperation with, universities and institutes of higher learning and staffed with specialists from a range of disciplines to undertake systematic curriculum development work and its continual evaluation in relation to current educational objectives.

Incentive systems should be devised that encourage curriculum development and maintenance. Professional and economic rewards should encourage potential authors, often working with others in an interdisciplinary group, to develop instructional systems. Recognition of quality work should be a factor in determination of promotion or other advantages. Economic incentives require establishing or improving copyright regulations for new media, including computer software.

Satisfactory methods for the long-term sponsorship, publication and distribution of learning materials must be devised which meet the pattern of user demand and maintain commercial viability.

Guidelines for Current Uses

Five kinds of computer use are recommended in the following advice adapted from An Evaluative Review of Instructional Use Of Computers by Karl L. Zinn, University of Michigan, Ann Arbor, 1970.

The use of the computer by students as a tool for learning and problem solving can be recommended strongly. This kind of use accounts for a large proportion of budget allocations to computing for instruction; assistance through computation, modeling and simulation appears to obtain a great improvement in academic performance and a favorable change in attitude in return for a small investment in faculty time and institutional computing resources.

Computer assistance with the management of study records and learning materials, by students directly as well as by teachers and administrators, is a promising application. Any program of instruction which allows some flexibility in learning approach involves records of student performance and information about materials and learning activities. When large and complex files have been assembled, computer assistance is required for economy, reliability and accessability.

Some students have special needs for whom the presentation of instruction (exposition or remediation) by computer may contribute significantly to learning and favorable attitude. When a student lacks motivation or suitable orientation to the ordinary self-instruction resources, the machine presentation provides a gentle pressure to proceed and to respond at each point of the sequence of instruction. For students lacking essential skills and opportunities for learning from present day language laboratories and group instruction, the careful sequencing and additional response processing done by computer systems appear to help.

Research on instruction and the development of instructional material should be pursued with computer assistance. For example, automatic processing of data on student performance and attitude helps the authors of curriculum materials attend to the interests and abilities of students.

New information processing techniques for providing diagnostic, tutorial, and other aids to individual learners should be explored. The application of findings in the computer science areas of artificial intelligence, natural language processing, and question answering systems should be pursued vigorously for the benefit of educational uses.

RECOMMENDATIONS FOR INSTRUCTIONAL COMPUTING AT THE UNIVERSITY

During 1970-71 a subcommittee of the University Committee on Computer Policy and Utilization examined needs and resources for instructional computing on campus. Members of the subcommittee were: Harold Borkin, Gregory Marks, Gordon Nordby, Richard Phillips (Chairman, 1971) and Karl Zinn (Chairman, 1970).

As a result of this work the Committee recommended:

> establishing responsibility for consultation on instructional computer services;
>
> encouraging closer ties between the Computing Center, the Center for Research on Learning and Teaching, and other units concerned with instructional computing;
>
> encouraging release time or other incentives for faculty development of instructional applications of computers;
>
> providing informational seminars for deans and department heads on the nature and long-range benefits of computer-related instruction.

Although no administrative action was taken on the recommendation, primarily because of budget limitations, indirect benefits did result from increased communication among units and individuals concerned with instructional computing and from information distributed to deans and department heads. Part of the text of the statement by the subcommittee as communicated to the Committee April 5, 1971, follows.

Recommendations for Instructional Computer Services

The subcommittee on Instructional Uses was charged by the full Committee with the task of recommending means for improving and increasing instructional uses of the computer. It is important that increased instructional use of the computer be encouraged, both for reasons of economy and improved educational quality. Economies will be realized in several ways. For one, it will be possible to extend greatly the educational resource base without significant additions to the faculty. Experience at other universities has shown that this effect makes it possible to expand enrollment with the corresponding ratio of faculty additions being far less than usual. The MERIT computer network represents another economy feature. It is possible to share programs which have been developed elsewhere, thereby minimizing duplication of effort. As concerns educational quality, it is well known that there is a synergistic effect when the computer is brought into an instructional process; the benefits to the student are much more than proportional to his input of effort. Also, apart from the important attraction of novel media, there is an intrinsic value to adding computer-based instruction to the traditional educational media. A greater breadth of instructional resources will increase educational quality and effectiveness.

Currently, most instructors who wish to explore computer use in courses, even in a minor way, can not easily obtain programming assistance equipment, or financial support. The Center for Research on Learning and Teaching (CRLT) does assist in the initiation of new instructional programs, but limited funds are used selectively for new kinds of uses. It must be made possible, indeed attractive, for a prospective computer user to obtain assistance on any level, no matter how mundane and non-innovative his intended application may be. If he does not know how to program and does not need to learn for the intended application, he should be able to obtain what help he requires. If he needs a remote terminal for his instructional application but has no easy access to one, he should be able to borrow one. In general, the obstacles encountered by the neophyte in search of his special computing requirements must be eliminated. It is this class of problem to which the subcommittee has addressed itself. Several specific areas of service which should be made available have been identified.

Consultation and programming assistance should be provided to any instructor who wishes to initiate a project which utilizes the computer in teaching. Collaboration between instructor and consultant may extend over one to three semesters and involve complete programming services in the event that such assistance is necessary.

A source of funds for time released from teaching should be made available to projects which merit support for incorporating the computer into courses. This recommendation includes the provision that such support will only be available up to the time that a project becomes an operational portion of a course. The department or other appropriate budgetary unit should assume full responsibility for support of operational programs. From these funds it should be possible to provide a full time appointment for appropriate faculty (from this campus or elsewhere) who wish to devote substantial time to general concepts of computer-based instruction.

A repository of computer terminals and other types of devices for computer access and information storage should be maintained. This pool would serve a dual purpose: to make user terminals available for loan to faculty members who require equipment during developmental stages of work; and to place responsibility with a centralized unit for evaluating new equipment and keeping the faculty informed about which might be useful for instructional purposes. Efficient use of a large block of terminals can be realized in this way since they would seldom be inactive.

An information service should be established which would periodically keep the faculty informed of the latest developments in the field of computer-based teaching techniques. This service would take the form of regular informal seminars and a periodic newsletter which would describe recent developments on campus, in the MERIT computer network, and on the national scene. Information derived from expert appraisal and evaluation of current computer-based projects would be transmitted through this service.

A software research and maintenance program should be instituted which would deal with extending and modifying existing languages that are of particular value for instructional purposes, identifying and evaluating

new languages and software packages as they become available, and developing new languages and device support packages which are of special value in the MTS and MERIT environment.

A variety of other services and functions which should be available can be elaborated as subsets of these five areas.

A VIEW OF THE FUTURE

The science and technology of computing and automated information systems will result in continuing changes in the procedures and institutions of commerce, government, education and leisure. Throughout industrialized nations, computers are already essential to many activities which involve every man; banking and government services are only two examples. An educated person expects to have knowledge about the practices of automated information processing, and he wishes on occasions to exercise control over the machines and data files with which he must deal. Education and especially reeducation for new careers place heavy demands on society, and the economy and intellectual power provided by automated information systems may be important to the efficacy of the educational process itself.

The present technologies of instruction do not appear adequate to meet the rate of growth and the pace of change of technical subjects. Hardware systems, using television, films, and teaching machines are rigid in presentation and unresponsive to creative endeavors of students; the procedures are not well suited to handling goals set by learners themselves. Computer-assisted instruction, as defined by most of the research and development work to date, has neither made hardware systems more flexible nor adapted to the changing goals of education. Computing systems must be used in a new and creative way.

Trends in Computer Use

A new approach to technology should consider the following trends: learner selection of goals, new means for representation of knowledge, use of alogrithms in teaching and learning activities, convenient tools for access to information, and incorporation of training into performance situations.

The computer and associated information processing systems are tools of the academic elite insofar as its members accumulate and organize information and broadcast it to the masses in carefully arranged format and sequence. However, such systems can and should be made into tools for all who wish to learn, helping them to access and organize information for their particular purposes and to seek answers to questions important to them.

Control by the instructional program will be reduced, with the learner taking more initiative. He will make decisions about what he wants to accomplish and what general means he wishes to try; he will interact with procedures stored in the computer to decide or negotiate the specific needs and procedures to be followed in learning activites; given a specific activity to pursue, he is likely to yield to the judgment embodied in the computer program.

Authors of programs will put minimal effort into diagnosis and prescription and much more into developing the representation of the subject matter and the means for interacting with it.

The intereaction between user and computer will be characterized by great responsiveness. The computer program will not simply respond quickly, but with substance that is appropriate to the action of the

learner. The learner should experience computing results through which his goals, needs and learning activities will be better served.

The variety of functions available to users will increase, especially in terms of tools relevant for a topic of study. Students will become more adept problem solvers through use of computer aids; upon completing a training or educational program they will be better prepared for jobs or future study than they would have been through highly structured tutorial programs.

The role of the computer for the student will be that of a tool for learning and scholarly work. The role of the computer for the teacher will become one of teaching aid rather than teacher replacement.

If these trends are realized, the results will help remove present obstructions to instructional use of computers. A shift in the technology as it is applied to computing in the instructional process can bring down the cost of computing per unit of learning and increase the attractiveness to students, teachers, and others making decisions about computer use. The attractiveness of computers in the learning process depends on greater flexibility in the use of the computer, including facilities for adaptation at the local level and greater responsiveness of the computer to actual needs and interests of students. Together, these improvements will support a situation in which the faculty member or researcher developing computer-related programs will be more likely to receive academic credit for his efforts, and the author and publisher of the text materials related to those computer programs will have some incentive to prepare materials well in order to obtain a tangible reward.

Costs and Related Resources

One might conclude from the cost of different educational resources today (e.g., libraries and laboratories) and the amounts individuals are willing to pay for entertainment or other things valued by them (e.g., color television and book clubs), that institutions will soon incorporate some amount of computing technology into regular educational activities, at least at the college level. If colleges and universities do not provide computing aids for learning, commercial interests will; an hour of computer fun and games could be available for 50¢ among the pin ball machines in the campus recreation spot.

College libraries already are changing facilities and activities to keep up with technology for education and research. Libraries have become less passive, less concerned with storage and classification, and no longer exclusively involved with books, card catelogs, and indices. Libraries have become actively involved in distribution activities, organizing knowledge and information, attending to new media such as microfilm and cassettes, incorporating search systems and current awareness services assure students access to computers and to data bases for any sound academic reason, just as they now claim extensive book collections.

Educational technology has been criticized for placing a brick between the learned and the domain of study. An alternate technology should remove the bricks from that wall in order to allow the construction of

channels of communication between the knowledge base and the learner. The basic tools of educational technology are needed in an innovative computer technology as much as for the analytical approach of programmed instruction. One hopes to apply the skills of behavioral and information scientists to the problem of communication between students and carefully organized information bases. Additionally, one hopes to establish channels of communication through the knowledge base to those scholars and scientists who contribute their knowledge to it.

APPENDIX A.
SELECTED READINGS ON COMPUTERS IN COLLEGE TEACHING

Reviews, Surveys and Collections

Hickey, Albert E. Computer Assisted Instruction: A Survey of the Literature. Third edition, Newburyport, Massachusetts, ENTELEK, 1968. $8.00.

Drawing from the files of the ENTELEK indexing and abstracting service, Hickey provides a comprehensive treatment of ongoing research, giving appropriate attention to research reports and documentation of instructional materials which have been prepared and tested.

Holtzman, Wayne H., ed. Computer-Assisted Instruction, Testing and Guidance. New York: Harper & Row, 1970. $10.00.

The twenty papers in this book were prepared for a conference at the University of Texas at Austin in October, 1968, organized by the Social Science Research Council and the College Entrance Examination Board. They encompass a wide range of subject areas including: system and instructional design, learning strategies, complex man-machine systems, and computer guidance and counseling. Although a number of the papers are technical and require some expertise in computer technology, the critical discussions are of general interest and are comprehensible to a novice in the field.

International Federation for Information Processing (IFIP). World Conference on Computer Education, edited by R. Schoepmaker and K. Zinn. Amsterdam: IFIP, 1970. $45.00.

The IFIP World Conference provided a valuable and timely opportunity for people from many countries to meet and discuss educational problems which are of universal importance. Recommendations for promoting computer education on a world-wide basis came out of the meeting, with specific proposals for educators and government authorities. Available in Europe from Wollers-Noordhoff, Groninger, The Netherlands; elsewhere from Science Associates/International, 23 E. 76th Street, New York, N.Y. 10010.

Lekan, Helen A., ed. Index to Computer Assisted Instruction, 3rd Edition, prepared at the Instructional Media Laboratory, The University of Wisconsin, published by Harcourt-Brace-Javenovitch, New York, New York. $19.50.

This edition is a compilation of over 1200 CAI programs from about 100 sources prepared for the several levels of education in both the sciences and the humanities. The programs are cross-referenced according to subject, computer required, programming language used, instructional logic and institution producing the program. A third edition is in press for 1974.

Levien, Roger. Computers in Instruction: Their Future for Higher Education, Proceedings of a Conference, Rand Corporation, October 1970.

About 25 contributions were arranged to consider computer capabilities and costs, sources of service, source of instructional materials, impact on higher education and policy recommendations. This proceedings is the single most important collection of statements about computers in higher education. Available for $5 from Rand Corporation, 1700 Main Street, Santa Monica, California.

Silberman, H.F. and Filep, R.T., "Information Systems Applications in Education," Annual Review of Information Science and Technology, Vol. 3, edited by Carlos Cuadra. Chicago: Encyclopaedia Britannica Inc., 1968.

In a very scholarly review Silberman and Filep discuss CAI, CMI, counseling, testing administration and educational data processing, and describe current operational systems as well as areas of research and development activity. Another Annual Review chapter is expected in 1974 by Vinsonhaler and Moon.

Zinn, Karl L., "Comparative Study of Languages for Programming Interactive Use of Compters in Instruction." EDUCOM Research Memorandum, prepared for the Office of Naval Research, Washington, D.C., 1969.

The study describes the language needs and objectives of various users of computers for instructional purposes, as well as describe and partially evaluate the languages themselves. Available from the Clearinghouse for Scientific and Technical Information, Springfield, Virginia, 22151. Order Number AD-692 506. About $6.

Zinn, Karl L. An Evaluative Review of Uses of Computers in Instruction. Ann Arbor. Center for Research on Learning and Teaching, University of Michigan, December 1970.

The final report of Project CLUE (Computer Learning under Evaluation), providing a current description of activities in this field. Appendix A of Volume I (Guide to Information Sources) is particularly useful for tracking down information about computer uses and technology. Available from ERIC Clearinghouse on Educational Media and Technology, Cypress Hall, Stanford, California 94305, microfische; multilith copy from Zinn, 109 E. Madison Street, Ann Arbor, Michigan 48104. $5.00.

Specific Recommendations Regarding Use of Computer

Great Britain. National Council for Educational Technology. Proceedings of A Seminar on Computer-Based Learning Systems. London, National Council for Educational Technology (NCET), 1970.

This five-day seminar on the role of computers in education was sponsored by NCET and the U.S. Office of Naval Research. A relevant and interesting proceedings, it brings together research being done in Belgium, Canada, France, Holland, the United Kingdom, and the United States. Papers in the Proceedings are organized by subject area. Copies may be ordered from Books for Schools, LTD., 10 Queen Anne Street, London WIM 9LD.

The NCET has also published Computer-Based Learning Systems: A Programme for Research and Development and a series of working papers on computers in education. The NCET is located at 160 Great Portland Street, London WI.

Organization for Economic Cooperation and Development. Seminar on the Use of Computers in Higher Education, Portland, Oregon, 1970. Paris: Organization for Economic Cooperation and Development (OECD), 1971.

This seminar was organized by the U.S. Office of Education and the Northwest Regional Educational Laboratory with a subsidy from the National Science Foundation; it was attended by experts from Europe, the Far East, and the United States. The proceedings contain an overview of current activities in computers and instruction along with some recommendations for internationalizing and exchanging research and experiences. The OECD is located at 2 rue Andre-Pascal, Paris XVI, France.

United Nations Educational, Scientific, and Cultural Organization. Consultation on Computer-Assisted Instruction for Developing Countries. Final Report. Paris: UNESCO, 1970.

In response to a number of inquiries about computers in instruction from developing countries, UNESCO called together experts in this field for a consultation session in Paris, March 16-18, 1970. Experts from around the world were asked to comment on fourteen important questions prepared by the UNESCO secretariat and to consider a large-scale CAI project in Spain. This report is a good international review of the current state of computers in education and includes guidelines and it is intended to be helpful to developing countries especially.

Educom Study of Obstructions to More Widespread Use of CAI. Ernest Anastasio. Educom, Princeton, New Jersey, 1972.

Report of a study conducted by questionnaires and a working meeting of experts in October, 1971.

Instructional Technology Committee of the Commission on Education of the National Academy of Engineering. "Educational Technology in Higher Education: The Promises and Limitations of ITV and CAI." Washington, D.C., 1969.

This brief and easy-to-read reports was designed for faculty members of engineering schools. It consists of four sections: The Promise of Educational Technology, The Problems of Higher Education, Funding Prospects, and the Role of the Engineering School. The two appendices provide background information for the four selected topics.

Levien, Roger. Computers in Higher Education: The Emerging Technology. McGraw-Hill, 1972.

Final report of a study for the Carnegie Commission on Higher Education.

Reports of Use and Interpretations for Specific Disciplines

Bowles, Edmund A., ed. Computers in Humanistic Research: Readings and Perspectives. Englewood Cliffs: Prentice-Hall, Inc., 1967. $7.95.

A collection of papers from six regional conferences in the United States dealing with the role of the computer in humanistic research. Contents includes surveys of the varied uses of the computer in anthropology, archaeology, history, political science, language and literature, and musicology, as well as discussions of the special problems confronting a humanist scholar dealing with computer research. Most of the articles are written in non-technical language and are comprehensible to lay readers.

Blum, Ronald, ed. Computers in Undergraduate Science Education, Proceedings of a Conference held in Chicago in August, 1970. College Park, Maryland: Commission on College Physics, 1971.

This volume contains 30 of the papers delivered at a conference organized by the Commission on College Physics and the Illinois Institute of Technology. A variety of contributions are arranged under the headings: computational mode, computer graphics, simulation mode, analogue computing, computer-supervised instruction, politics and practice, and the future. It replaces the widely-distributed report of a 1965 conference organized by the Commission. Although it is at the moment the best single source on computers in physics and math teaching (the coverage is not as broad as indicated in the title), more current reports appear each year in the physics and math sections on the Conference on Computers in the Undergraduate Curricula.

Funding for the Commission on College Physics was concluded in 1972, and the reports and some of the activities of the Commission have been taken over by the American Institute of Physics. The conference proceedings is available from AIP at 335 East 45th Street, New York, NY 10017.

Instructional Technology Committee of the Commission on Education of the National Academy of Engineering. Report. "Educational Technology in Higher Education: The Promises and Limitations of ITV and CAI." Washington, D.C., 1969.

This brief and easy-to-read report was designed for faculty members of engineering schools. It consists of four sections: The Promise of Educational Technology, The Problems of Higher Education, Funding Prospects, and the Role of the Engineering School. The two appendices provide background information for the four selected topics.

Kurtz, Thomas E., ed. Conference on Computers in the Undergraduate Curricula. Hanover: Dartmouth College, June 1971. $5.00.

The Conference on Computers in the Undergraduate Curricula has become an annual event. There are approximately 80 papers in the 1971 collection, describing a wide variety of ideas and techniques for improving the teaching of traditional subjects through adjunctive use of the computer. See also Weeg and Hambler in this section.

Stolurow, Lawrence M., Peterson, Theodore I., and Cunningham, Anne C., eds. Computer Assisted Instruction in the Health Professions. Newburyport, Massachusetts: ENTELEK, 1970.

This volume contains about 30 papers from the proceedings of a conference at the Harvard School of Medicine in 1968, supported by the Office of Naval Research. They discuss general educational requirements, computer use in pre-clinical and clinical education, and describe existing and developing methodology and systems.

Weeg, G.P., ed. Proceedings of a Conference on Computers in the Undergraduate Curricula. Iowa City: The University of Iowa, June 1970. $5.00.

Includes papers by some eighty faculty members of undergraduate programs from colleges representing most academic as well as geographic areas of the nation. They present here their actual experiences in making the computer a central issue in their course work, interpreting their own successes and failures and advising on programs worth trying and avoiding.

Hamblen, J., ed. Proceedings of a Conference on Computers in the Undergraduate Curriculum. 1972. $6.00.

APPENDIX B: UNIVERSITY EXPENDITURES FOR INSTRUCTIONAL COMPUTING

July 1, 1971 through June 30, 1972*

Revenue Deriving Services

University Supported Instructional and Research Uses:		
Main and Dearborn Campuses		
Student use for course projects		$555,440.20
Student use for thesis research		278,224.98
Academic staff use for research, course development, and administration		602,491.95
	(Subtotal)	$1,436,157.13
Off-Campus (UM-Flint)		
Student use for course projects		$11,426.23
Academic staff use for research, course development, and administration		15,083.82
	(Subtotal)	$26,510.05
	(Total)	$1,462,667.18
Sponsored Research and University Administrative Uses:		$1,261,473.49
Total Revenue From All Sources		$2,724,140.67

MERIT Network Exchange

Use through the Network (balance):		
Michigan State University		3,070.43
Wayne State University		4,481.12
	(Total)	$7,551.55

System Operations & Maintenance

System Operations and Maintenance	$671,155.85

* Taken from the 1971-72 Annual Report of the University of Michigan Computing Center.

Expenditures by unit (arranged in order of magnitude, rounded to nearest $100)

Computer and Communication Sciences (LSA)	$104,400
Business Administration	55,700
Industrial Engineering (Engineering)	41,200
Electrical Engineering (Engineering)	31,900
Freshman Computer Courses (Engineering)	28,500
Architecture and Design	25,000
Political Science (LSA)	22,500
Political Science Consortium (LSA)	22,000
Medical School (and attached units)	18,600
Sociology (LSA)	17,900
Civil Engineering (Engineering)	13,600
Natural Resources	13,300
Psychology (LSA)	11,900
Naval Architecture and Marine Engineering (Engineering)	10,600
CIC Engineering (Engineering)	10,500
Mechanical Engineering (Engineering)	10,500
Mathematics (LSA)	9,800
Chemical Engineering (Engineering)	8,300
Statistics (LSA)	7,100
Economics (LSA)	6,500
Education	6,400
Geography (LSA)	5,900
Library Science	5,800
Journalism (LSA)	3,900
Physics (LSA)	3,500
Nuclear Engineering (Engineering)	3,200

History (LSA)	2,700
Meteorology & Oceanography (Engineering)	2,700
Zoology (LSA)	2,700
Aerospace Engineering (Engineering)	2,500
Environmental & Industrial Health (Public Health)	2,300
Nursing	2,100
Chemistry (LSA)	2,000
Health Development (Public Health)	1,900
Anthropology (LSA)	1,500
Biostatistics (Public Health)	1,400
Materials & Metallurgical Engineering (Engineering)	1,400
Astronomy (LSA)	1,300
Linguistics (LSA)	1,100
Social Work	1,100
Hospital Administration (Public Health)	1,000
Music School	800
Bioengineering (Engineering)	700
Residential College (LSA)	600
Geology & Mineralogy (LSA)	500
Dentistry	500
Medical Care Organizations (Public Health)	400
Population Planning (Public Health)	300
Engineering Mechanics (Engineering)	300
Community Health Services (Public Health)	200
Health Planning (Public Health)	100
Botany (LSA)	100

Totals for LSA departments do not include sections at Dearborn Campus and Flint College

APPENDIX C: SCHOOLS, DEPARTMENTS AND OFFICES REPORTING USE OF COMPUTERS FOR INSTRUCTION

School of Architecture and Design
School of Business Administration
Center for Research on Learning and Teaching
Computer Center

Dearborn Campus
- Mathematics
- Natural Sciences
- Social Sciences
- Business Administration
- Engineering

School of Dentistry
School of Education
College of Engineering
- Aerospace Engineering
- Computer Graphics Laboratory
- Computer, Information and Control Engineering
- Continuing Engineering Education
- Electrical Engineering
- Industrial Engineering
- Mechanical Engineeri
- Meterology and Oceanography
- Naval Architecture
- Systems Engineering Laboratory

Flint College

- Biology
- Business Administration
- Chemistry
- Economics
- English
- Foreign Languages
- Geography
- History
- Mathematics
- Philosophy
- Physics
- Political Science
- Psychology
- Sociology
- Urban Studies

Institute of Labor and Industrial Relations
Institute for Public Policy Studies
Institute of Science and Technology
- Highway Safety Research Institute
- MERIT Computer Network

Law School
Libraries
Library Science
College of Literature, Science, and the Arts
- Anthropology
- Chemistry
- Computer and Communication Science
- Economics
- Geography
- Geology and Minerology
- History
- Journalism
- Mathematics
- Physics
- Political Science
- Inter-University Consortium for Political Science
- Psychology
- Zoology

College of Medicine
- Biological Chemistry
- Biomathematics Biomedicine Program
- Human Genetics
- Internal Medicine-Nuclear Medicine
- Mental Health Research Institute
- Pathology
- Physical Medicine and Rehabilitation

School of Music
School of Natural Resources
- Environmental Simulation Laboratory
- Landscape Architecture

School of Public Health
Statistical Research Laboratory